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FREEZING-DRIED TETRACAINE HYDROCHLORIDE POWDER INJECTION (English)
Patent Assignee: ZHEJIANG PROV TRADITIONAL CHIN (CN)
Author (Inventor): JIN DAYUAN (CN)
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Making field emission electron source employing diamond coating - having carbon ions implanted at surface of conductive semiconductive electrode to function as nucleation sites for diamond formation

Patent Assignee: MOTOROLA INC (MOTI); JASKIE J E (JASK-I)
Inventor: JASKIE J E; KANE R C
Number of Countries: 016 Number of Patents: 009
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Patent No	Kind	Date	Applicat No	Kind	Date	Week	
US 5141460	A	19920825	US 91747563	A	19910820	199237	B
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ES 2096687	T3	19970316	EP 92113953	A	19920817	199718	
RU 2083018	C1	19970627	SU 5052501	A	19920731	199805	

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Abstract (Basic): US 5141460 A

The method for forming a field emission electron emitter includes the steps of providing a selectively shaped conductive/semiconductive electrode having a major surface, implanting ions, as nucleation sites, onto at least a part of the major surface of the conductive/semiconductive electrode, and growing diamond crystallites, preferentially at at least some of the nucleation sites.

An electron emitter comprising a coating of diamond disposed on at least a part of the major surface of the selectively shaped conductive/semiconductive electrode is formed. An emission controlling electrode is proximally disposed with respect to the electron emitter for controlling the emission rate of electrons from the electron emitter; and an anode collects emitted electrons.

ADVANTAGE - Improved surface stability, susceptibility to ion bombardment.

Dwg.4/6

Title Terms: FIELD; EMIT; ELECTRON; SOURCE; EMPLOY; DIAMOND; COATING; CARBON; ION; IMPLANT; SURFACE; CONDUCTING; SEMICONDUCTOR; ELECTRODE; FUNCTION; NUCLEATE; SITE; DIAMOND; FORMATION

Derwent Class: U11; U12; V05

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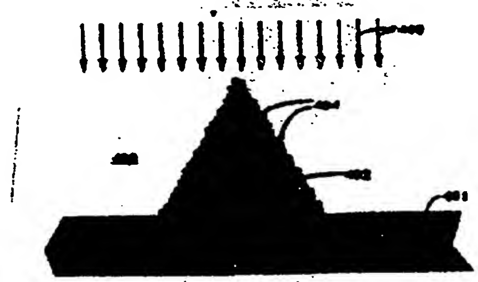
说明书页数: 8 附图页数: 11

[54]发明名称 采用金刚石覆层的场致发射电子源及其制造方法

[57]摘要

本发明为一场致发射电子装置，该装置采用了一个包括一个金刚石材料覆层的电子发射器，上述的金刚石覆层位于有选择地形成的导电/半导体电极(402)的表面上。本发明还涉及形成该装置的方法，该方法包括将碳离子植入导体半导体电极的一个表面使之在金刚石形成时得到成核点的作用这一步骤。



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权 利 要 求 书

1．一种形成一个场致发射型电子发射器的方法，其特征在于：

提供一个具有一个主表面的、具有选定形状的导体/半导体电极，

以成核点（404）的形式在上述的导体/半导体电极（402）的至少一部分主表面上植入离子，

在至少一些上述的成核点（404）上有选择起进行金刚石晶粒（406）生长，从而形成一个包括一个设置在具有选定形状的导体/半导体电极的至少部分主表面上的金钢石覆层的电子发射器。

2. 如权利要求1中所述的方法，其特征还在于，上述的离子植入步骤中包括植入碳离子。

3. 如权利要求1中所述的方法，其特征还在于：上述的提供导体/半导体电极这一步骤中还包括对半导体材料进行的各相异性蚀刻。

4. 如权利要求1中所述的方法，其特征还在于下列步骤：

提供一个支撑基板（401），

在上述的支撑基板（01）上沉积一层可成形材料（403），

使可成形材料层（403）成形，从而在其上提供一个通孔

(409)，

提供一个基本上设置在通孔（409）内部、支撑基板(401)上面的具有选定形状的导体/半导体电极(402)，

执行离子植入步骤(404)，并且

去掉全部可成形材料层(403)，在些步骤之后再执行金刚石晶粒(406)生长步骤。

5. 如权利要求4中所述的方法，其特征还在于：上述的提供导体/半导体电极(402)这一步骤中包括下面的步骤：通过基本上是普通的导电/半导体材料的沉积未形成电极。

6. 如权利要求4中所述的方法，其特征还在于：上述的离子玫步骤包括下列步骤：

在上述的可成形材料构成的已成形层上沉积一层导体/半导体材料，

提供离子植入设备(640)，

将上述的导电/半导体电极（602）设置在离子植入装置(640)中，并将离子以成核点的形式植入上述的导电/半导体电极(602)的至少部分表面上，

在支撑基板(601)的离子植入设置(640)之间提供一个第一电压源(610)，从而在离子植入设备(640)和导电/半导体电极(602)之间提供一个加速电场，以及

在上述的支撑基板(601)和导电/半导体层(607)之间提供一

个第二电源，从而在上述的导电/半导体层(607)和导电/半导体电极(602)之间提供一个离子排斥电场，使得至少部分离子有选择地射向上述的导电/半导体电极(602)的选定部分。

7. 如权利要求 4 中所述的方法，其特征在于下列步骤：

在上述的可成形材料构成的已成形层上沉积一个导电/半导体材料层(607)，

使用低角度沉积工艺在上述的导电/半导体材料层(607)上沉积一个材料层(614)，从而使蚀刻出来的通孔(609)被有选择地部分掩闭，

在离子(604)植入之后去除掉全部材料层(614)，从而使碳离子被基本上有选择地植在导电/半导体电极(602)的表面上的选定部分上。

8. 一种场致发射型电子发射器，其特征在于：

一个具有一个主表面的、有选择地形成的导电/半导体电极(402)，

设置在上述的导电/半导体电极(402)的主表面上的许多用于离子植入的成核点(404)，以及

至少一个设置在上述的导电/半导体电极(402)的主表面上并且处于上述的许多成核点中的一个成核点(404)上的金刚石晶粒(406)。

9. 如权利要求 8 中所述的场致发射型电子发射器，其特征在

于：设置在上述的主表面上的金刚石晶粒(406)形成了一个位于上述的导电/半导体电极(402)的至少一部分主表面上的基本均匀的金刚石覆层。

说　　　明　　　书

采用金刚石覆层的场致发射电子源及其制造方法

总的来说，本发明涉及场致发射电子装置，更具体地来说，是涉及场致发射电子装置以及制造采用低/负电子亲合势的电子装置的方法。

采用具有优选形状的导体/半导体电极作为电子发射器的场致发射装置是公知技术，这种现有的电子发射器同时也呈现一些不利的特性，如工作电压高，表面不稳定，以及易受离子轰击损害。等等。

因此，人们近切希望有一种具有能够克服现有电子源的至少部分缺点的电子发射器电子源的电子装置。

上述要求如其它要求通过提供一种形成场致发射或电子发射器的方法来加以满足。该方法包括如下步骤：提供一个具有一个主表面的、具有选定形成的导体/半导体电极，将离子作为成核点植入该导体/半导体电极的至少部分表面上，以及在至少部分成核点上可选择地使金刚石晶粒生长，从而形成一个包含一层设置在具有选定形状的导体/半导体电极的至少部分表面上的金刚石覆层的电子发射器。

上面的要求也可以通过提供一种场致发射电子装置来满足。该装置包括：一个带有一个有选择地形成的导体/半导体电极的场致发射式电子发射器，设置在上述导体/半导体电极的主表面上许多植入离子的成核点，至少一个设置在上述的导体/半导体电极的主表面上以及许多成核点中的一个上的第一金刚石晶粒，以及紧邻着电子发射器设置的，用于控制电子发射器的电子发射率的发射控制电极和用于收集被发射的电子的阳极。

图 1. 是离子注入装置的示意图。

图 2. 是离子注入装置的截面图，

图 3. 是金刚石生长环境装置。

图 4A—4C. 是通过执行本发明的一种方法的各个步骤而实现的结构的侧视图。

图 5A—5D. 是通过执行本发明的另一种方法的各个步骤而实现的结构的侧视图。

图 6A—6E. 是通过执行本发明的又一种方法的各个步骤而实现的结构的侧视图。

现在来参照图 1，图 1 中示出了离子注入装置的一个实施例的示意 图 。真空腔 101 内部设置了一个离子源 106 和一个基板（目标）夹持装置 103。另外，如图中所示，还设置了一个离子材料 源 壁孔 105 ，用以给离子源 106 提供材料 。抽真空口 102 可以与图中未示出的抽真空设备相连，以便对腔 101 进行抽真空。在注入装置工

作时，离子束 107 射向目标 104，由于由 电源 108 成立的电场的缘故，离子束 107 中的至少部分离子被注入在目标 104 上。

图 2 是其上/其中已被注入离子 201 的目标(基板)104 的侧视图，根据相应的加速电场(未示出)的强度，离子被有选择地注入到目标 104 的材料中的预定深度上，电场强度相应地也可以进 行选择，从而使被注入的离子基本上分布在目标 104 的表面。

图 3 是金刚石生长环境装置的一个实施例的示意图 。真空腔 301 内部设置了一个基板(目标物)夹持器 305 和一个加热元件 304。作为供气管的一部分的源管 33 将反应气体组成物源供入金刚石生长环境中 。通过将一台真空泵 (未示出)与抽真空口 302 相连可以将腔 301 适当地抽真空。工作时，基板 306 被设置到基板夹持器 305 上，并将加热元件 304 也设置在夹持器 305 附近，电源 307 产生电流流过加热元件 304，从而使基板 306 加热，在适当的气体组分存在时，在基板 306 的表面会发生一种能使金刚石生长的反应。

金刚石生长至少部分地与材料表面的成核能力有关，在许多金刚石的形成方法中，成核是随机发生的，分布也不均匀，这样就会造成不希望的、不完整的薄膜生长。注入在基片 306 的表面上的碳离子提供了许多分布基本均匀的成核位置，从这些位置上可以开始金刚石生长。

图 4A 中示出了通过执行本发明的各个步骤来实行的一种结

构400的侧视图，结构400包括由导电/半导体材料制成的具有选定形状的层401，该层401具有至少一个具有选定形状的主表面。在本实施形中，其形状是同来形成电极402的一个园锥形突起，层401的选择成形可以采用任何现有工艺包括(但不限制于这些工艺)不匀蚀刻和离子铣销等来进行，由箭头405所示的离子束在电极402的主表面提供了碳成核位置404。

另外，也可以象图4B那样，层401是一个支撑基板，上面设有一个由可成形(*patternable*)材料如感光树脂或者绝缘构成的、具有至少一个通孔409的层403。通孔409可以通过使感光、树脂成形交且显影或者按要求对绝缘材料进行蚀刻来选择地形成。导体/半导体电极402设置在通孔409内，层401之上。由箭头405所示的碳离子束在导体/半导体电极402在提供注入成核点404，层401的其余部分由层403加以保护，以防止成核点注入。在成核点404植入之后，可成形材料层403即被清除掉。

图4C是由上面描述的图4A和图4B中的结构400经过执行本发明的方法的另外几个步骤后得到的结构的侧视图。由箭头420所示的反应材料源被设置在导体/半导体电极400和一个毗邻加热元件(如图3中描述过的元件304)的中介区域，使得金刚石晶粒406能在植入的碳成核点上开始生长。

这样得到的上面有一层金刚石晶粒406覆层的导体/半导体电极402就构成了一个具有许多有利的工作特性的场致发射电子发

射器，这些有利的工作特性包括：电压工作低，表面稳定性好，并且不易遭受离子轰击损伤。碳成核点404的插入提供一种改进金刚石晶粒的覆盖并且抑制可论包括不希望的大晶粒生长的出现的机制。

图5A是通过执行本发明的另一种方法的各个步骤而实现的结构500的侧视图。其中设置了一块支撑基板501，在该基板501上，设置了一个由绝缘材料构成的、上面形成有一个通孔509的层508，根据前面描述过的图4A和4B形成的导体/半导体电极502设置在通孔509内支撑基板501之上。由导体/半导体材料层507设置在层508上，该基本上与通孔509相符合，并对之进行进一步限定，层507上又设置了一个可成形材料层522，由箭头505所示的碳离子来在导体/半导体电极502上提供成核点504的植入，在成核点504植入之后，层522即被清除掉。

或者也可以象图5B所示的那样，省掉图5A中所示的可成形层522，但结果是至少有一些成核点504附着在导体/半导体层507上。

图5C是图5A和5B中所述的那种500经过该方法的另外几个步骤处理之后的侧面剖面图。由箭头520表示的反应物质源设置在导体/半导体电极502和一个紧邻的加热元件(见图3)之间的交介区域中，从而使金刚石晶粒506在选下的碳成核点上生长。导体/半导体电极502与金刚石成核点506的结合产生了一种改进了的

电子发射器 510，

图 5*D* 是图 5*C* 中所示的结构 500 又加上了一个阳极 516 之后的侧面剖视图。阳极 516 设置在电子发射器 510 的远侧，用于收集由电子发射器 510 射出的任何电子。层 507 因为是由导电/半导体材料制成的，因此起到控制电极发射速度的发射制电极的作用。根据图 5*D* 中所示的本发明和方法形成的场致发射装置（结构 500）采用了一个包括金刚石覆层的电子发射器，可以有利地使用在本领域内公知的许多场合。通过植入成核点并使金刚石晶粒由此开始生长这一措施能提供更均匀的覆层。由于希望的覆层厚度的放置改为 10*A* 至 5000*A*。因此，覆层形成中的一个重要特点是覆层厚度和覆盖面中的不规则性应减至最小。其他一些实现金刚石薄膜生长的方法不能提供基本均匀的生长厚度和覆盖面。

图 6*A* 是一种前面根据图 5*B* 描述的结构相似的结构 600 的侧面剖视图，图中，在图 5*B* 中，已经描述过的相似的特征相应地以数字“6”开头进行标注。图 6*A* 还示出，离子注入源 640 提供一个离子束 605，碳成核点 604 就以这个离子束 605 被植入导体/半导体电极 602 的表面，在图 6*A* 所示的情况下，一个外接电源，610 接在离子注入源 640 的支撑基板 601 之间。第二个外接电源 612 接在导体/半导体层 607 和支撑基板 601 之间。图 6*A* 中的基板或者也可以采用一个如前述参照图 4*A* 描述的那种导体/半导体电极。通过向导体/半导体电极 607 施加一个适当的电压，离子束 605 中包

含的离子被从接近导体/半导体层607的边缘的区域排斥至导体/半导体电极602的表面的希望的小区域中，这种离子束605的重定向将使成核点604基本上只插入导体/半导体电极602的表面的选定区域上。

图6*B*是结构600的侧面剖视图，其中，一种不同的特征被用来达到图6*A*中所示的结果。在这个改进了的方法中，通过采用一种本技术领域内公知的低角度材料沉积技术提供一种部分闭合层614，使通孔609被部分封闭。由箭头605所示的碳离子束提供了在导体/半导体电极602上的插入的成核点604。

图6*C*示出了经过一个附加步骤即去除了掩闭层614之后的结构600。

图6*D*是结构600经过本发明的方法中其他步骤之后的侧面剖视图，在所述的其他步骤中，由箭头620所示的反应材料源被设置在导体/半导体电极602和一个毗邻的加热元件(见图3)之间的中介区域内，使金刚石晶粒606象希望的那样在插入的碳成核点上进行生长。在图6*D*所示结构的情况下，金刚石晶粒析生长只是在导体/半导体电极602的暴露部分的小部分上进行。导体/半导体电极602与金刚石晶粒606的覆层相结合能形成一种改进了的电子发射器610。

图6*E*是又加上了一个阳极616之后的结构600的侧面剖视图，阳极616被设置在电子发射器610的远端，用于收集由该电子

发射器610射出的电子。导体/半导体层607起到一个控制电极发射速率的发射控制电极的作用。根据图6A—图6E中所示的本发明的方法形成的场致发射装置采用包含金刚石覆层电子发射层，可以有利地使用在本技术领域内公知的许多场合下，采用植入成核点再使金刚石晶料由此开始生长的方法能够提供更均匀的覆层。由于希望的覆层厚度为10A的数量级之间，因此，覆层形成中的一个重要特征就是使覆层厚度和覆盖面的不规则性减至最小，其他能实现金刚石薄膜生长的方法不能提代基本均匀的生长厚度和覆盖面。

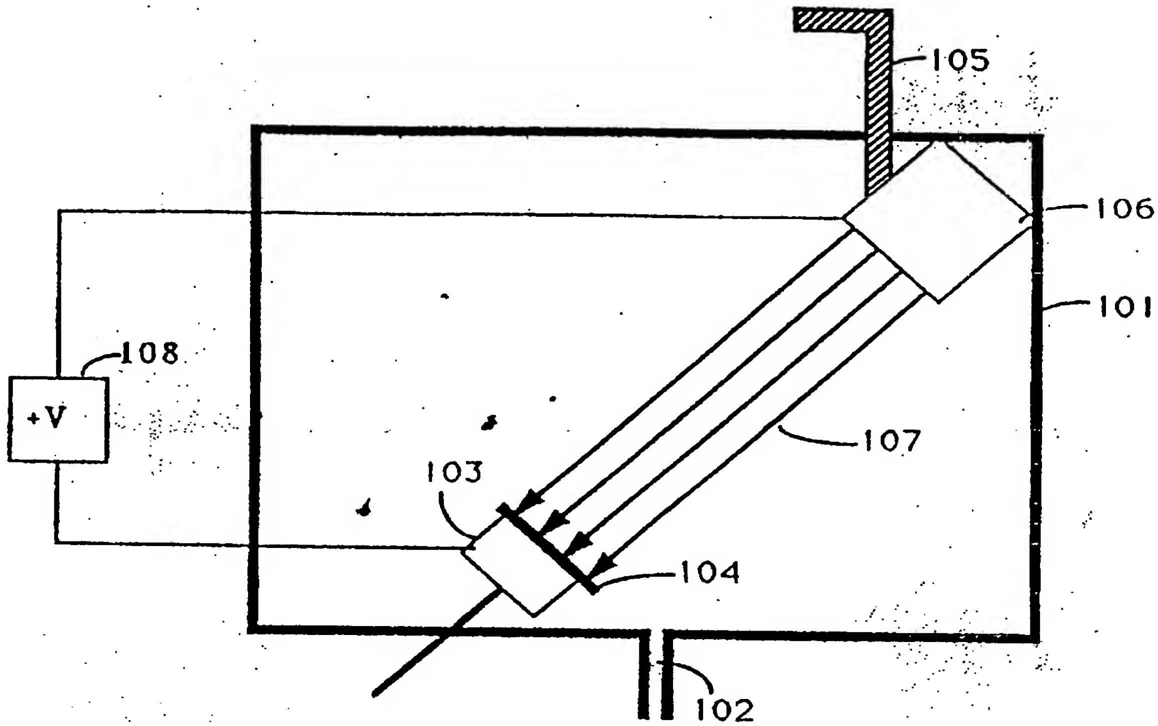

图. 1

图. 2

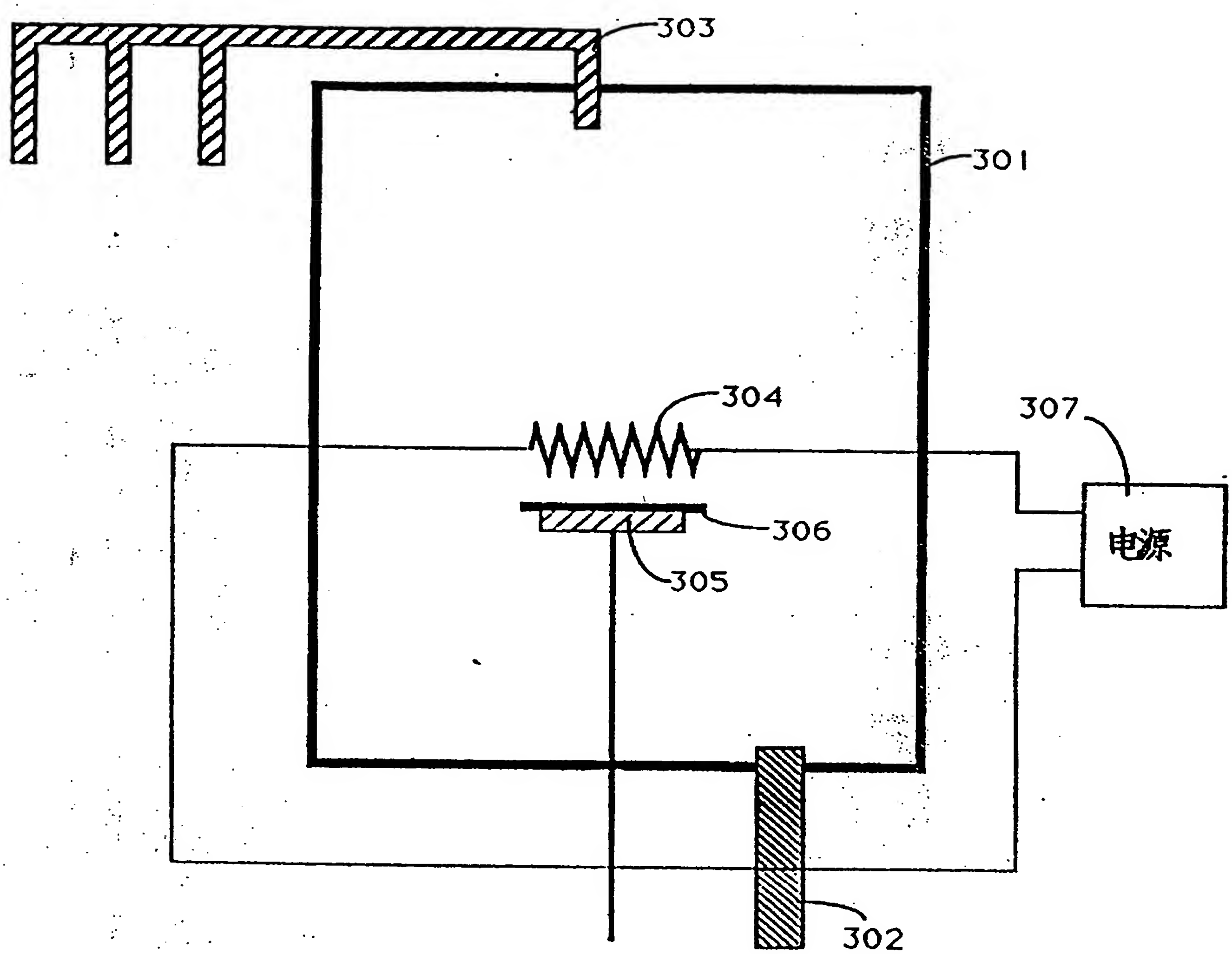

图. 3

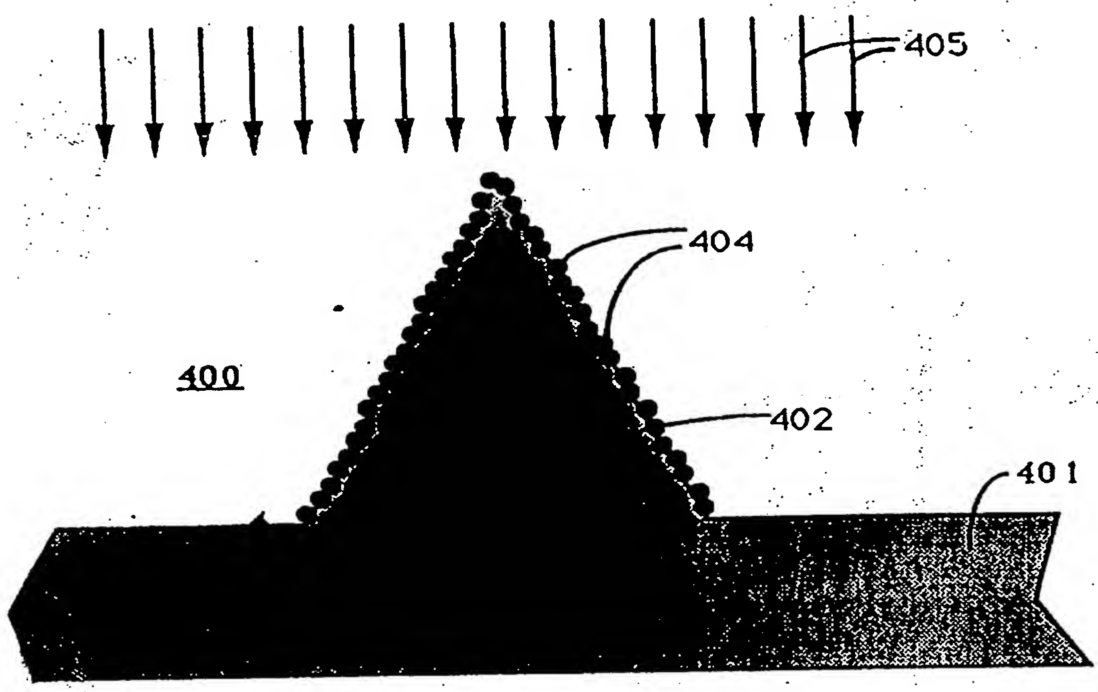

图. 4A

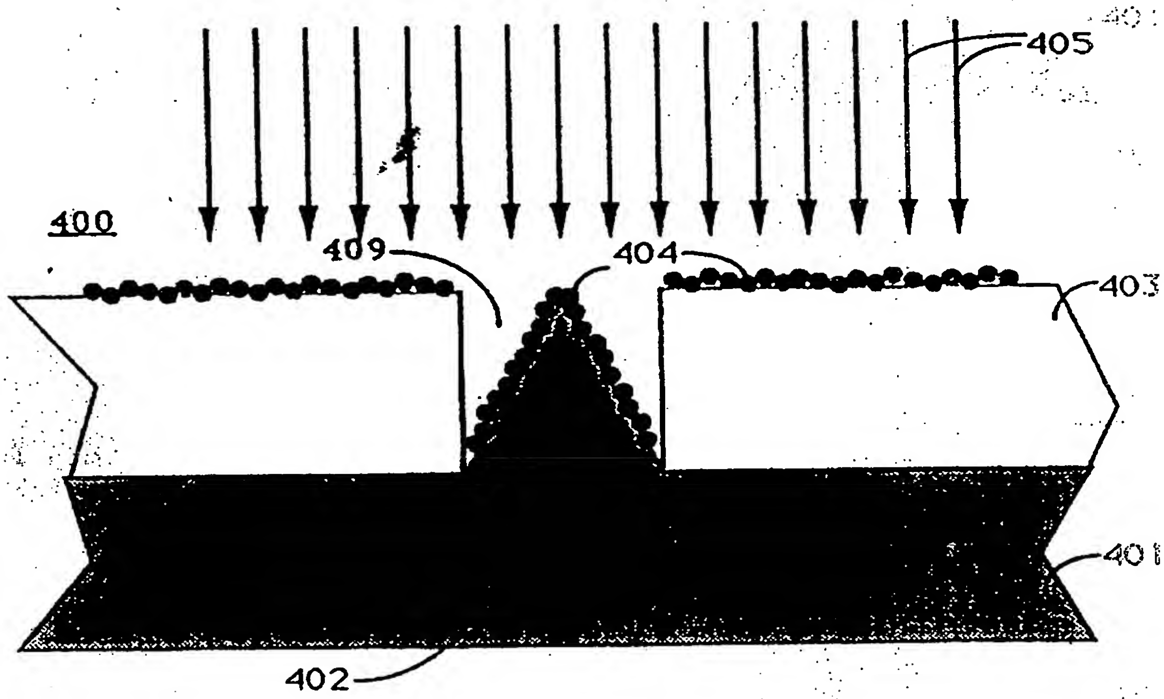

图. 4B

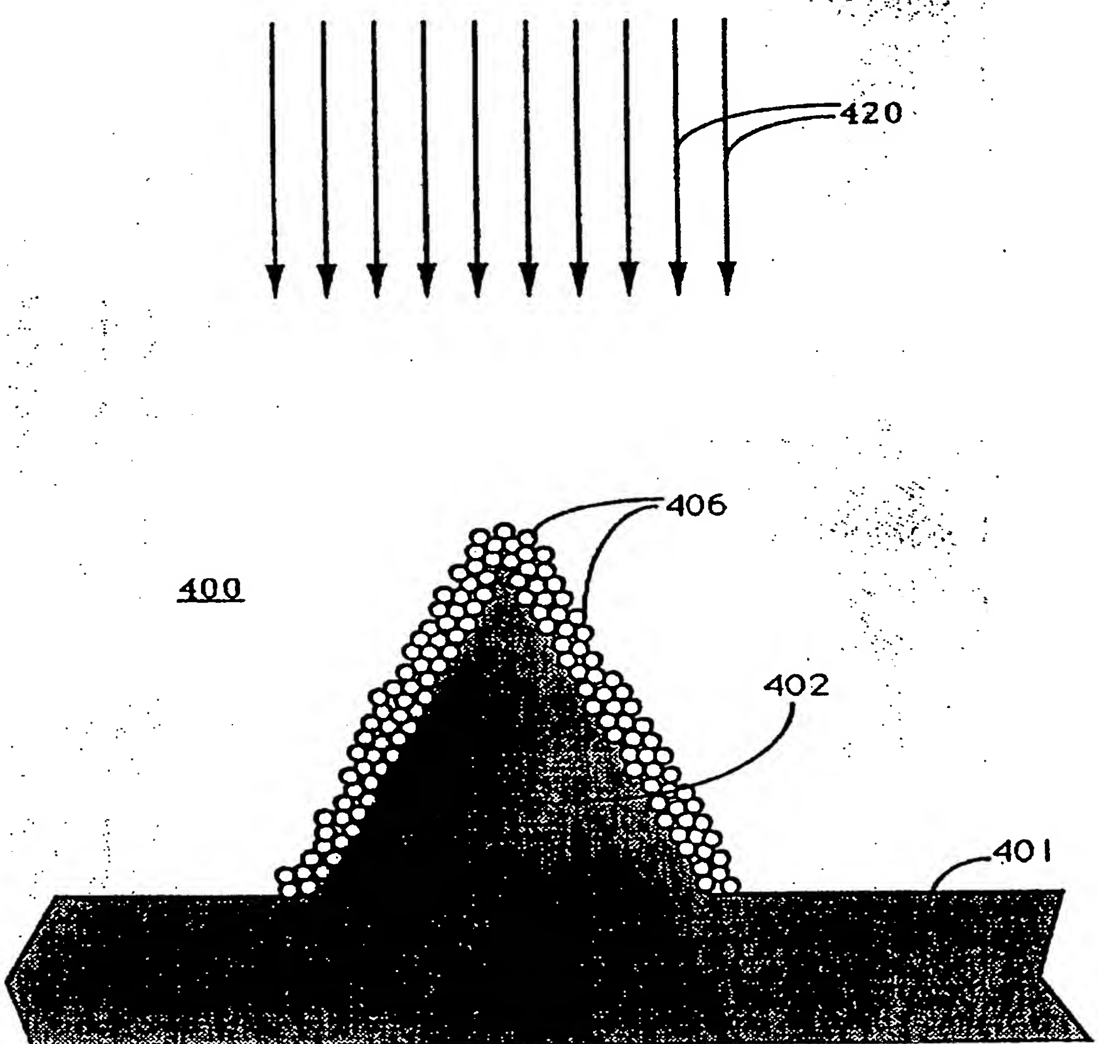

图. 4C

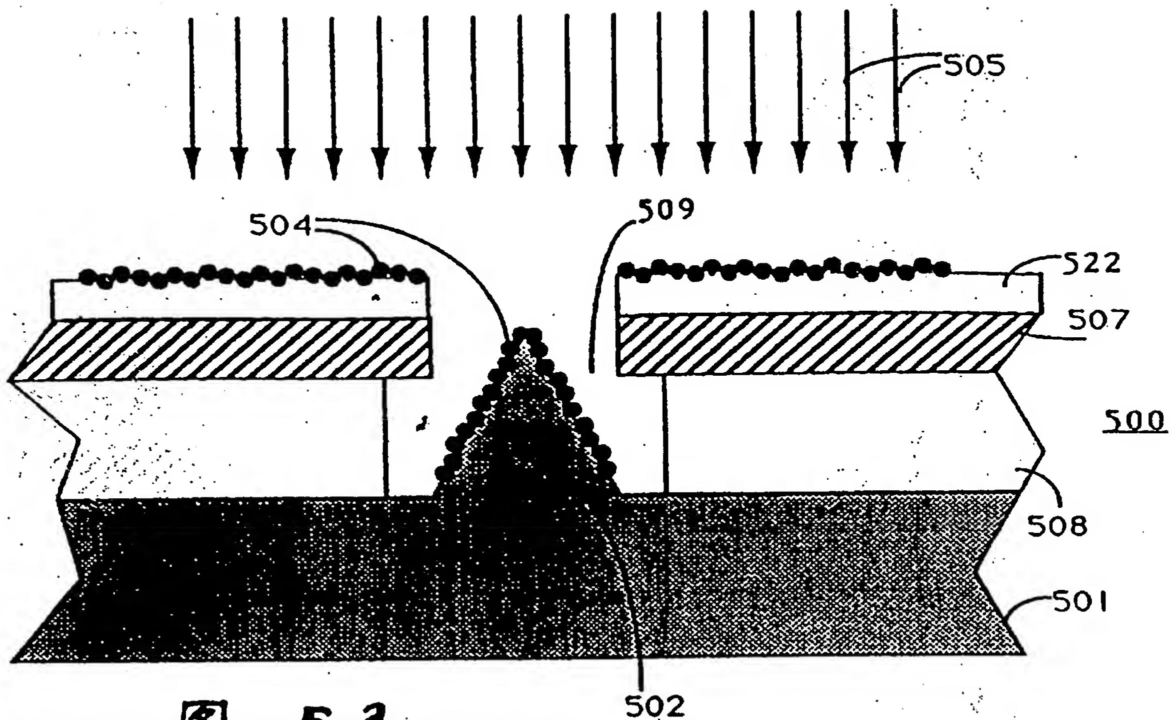

图. 5A

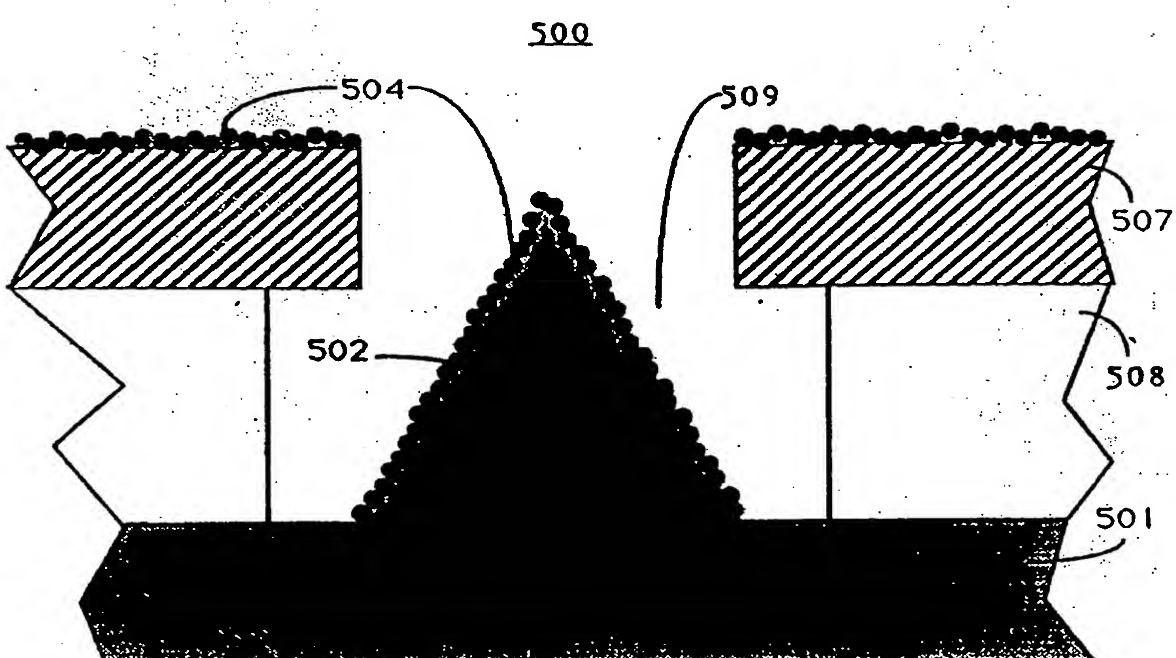

图. 5B

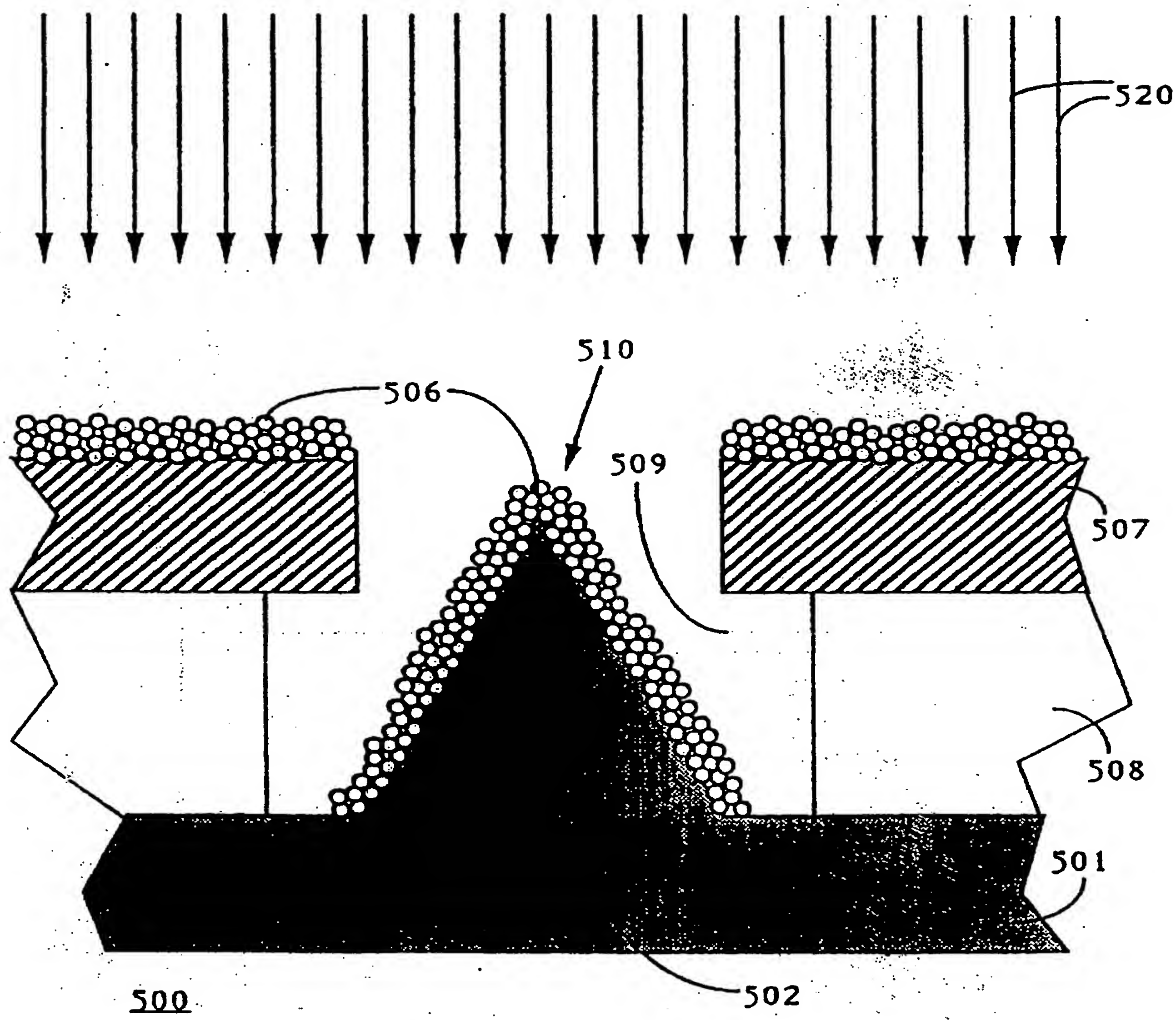

图. 5C

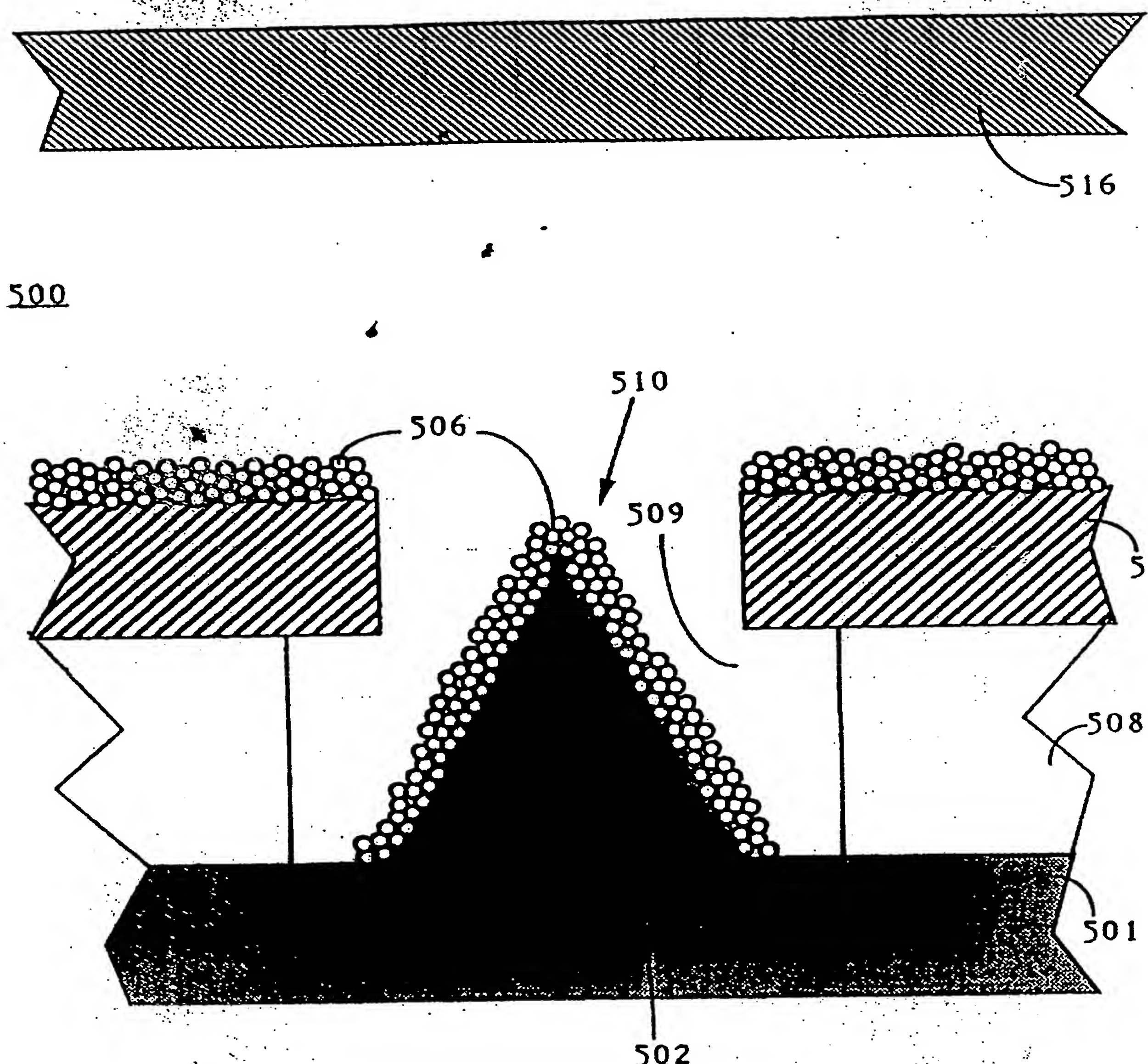

图. 5D

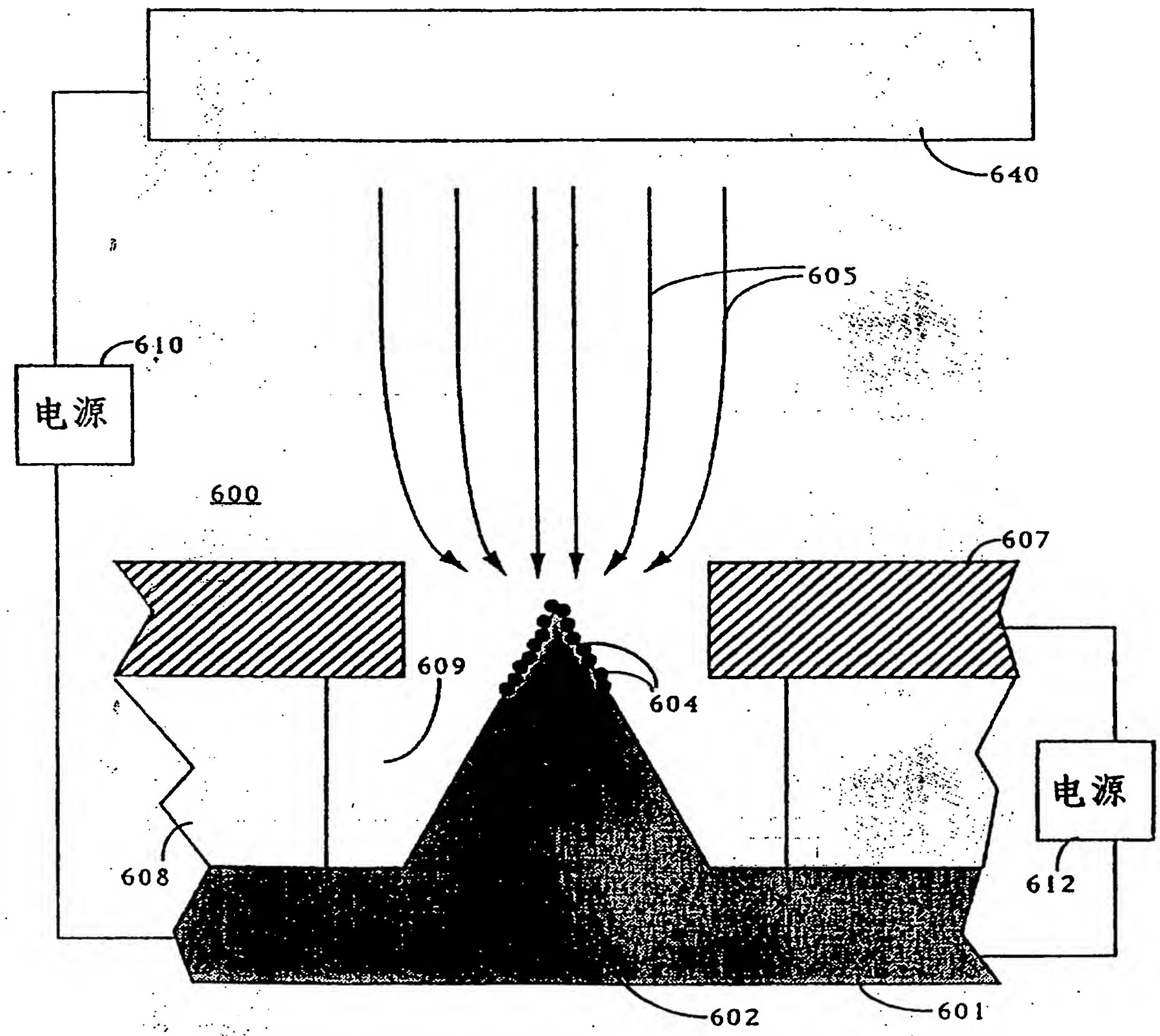

图. 6A

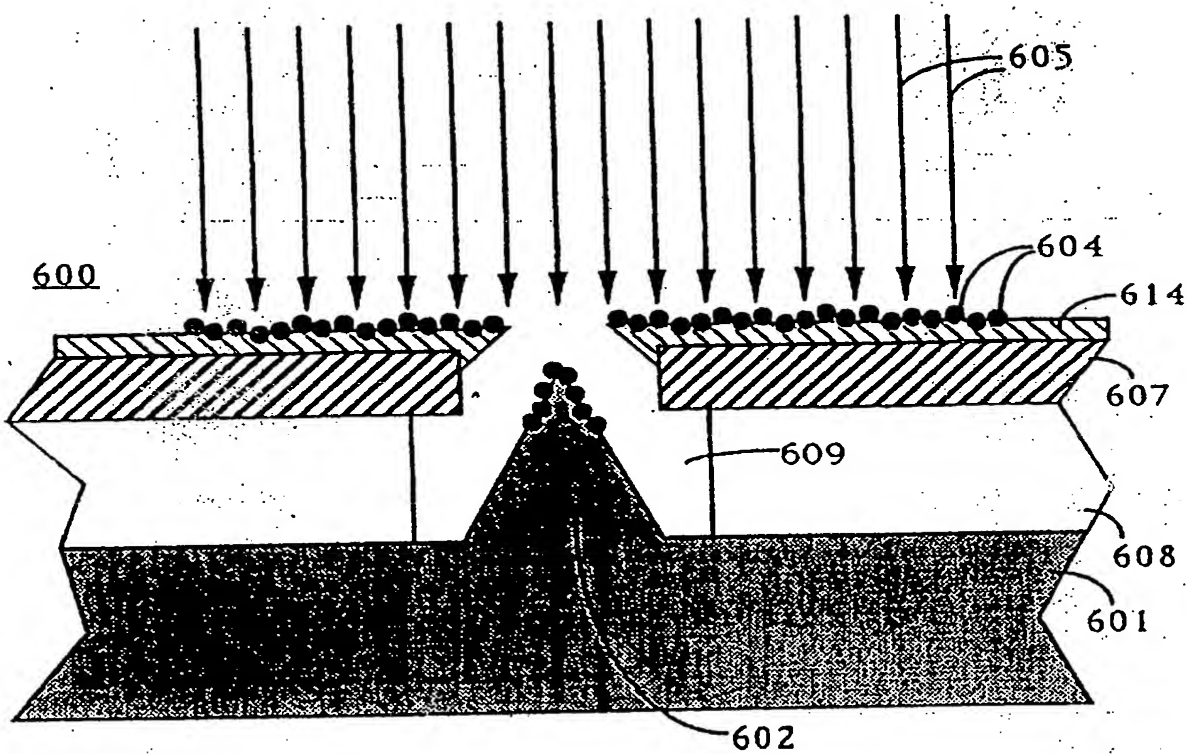

图. 6B

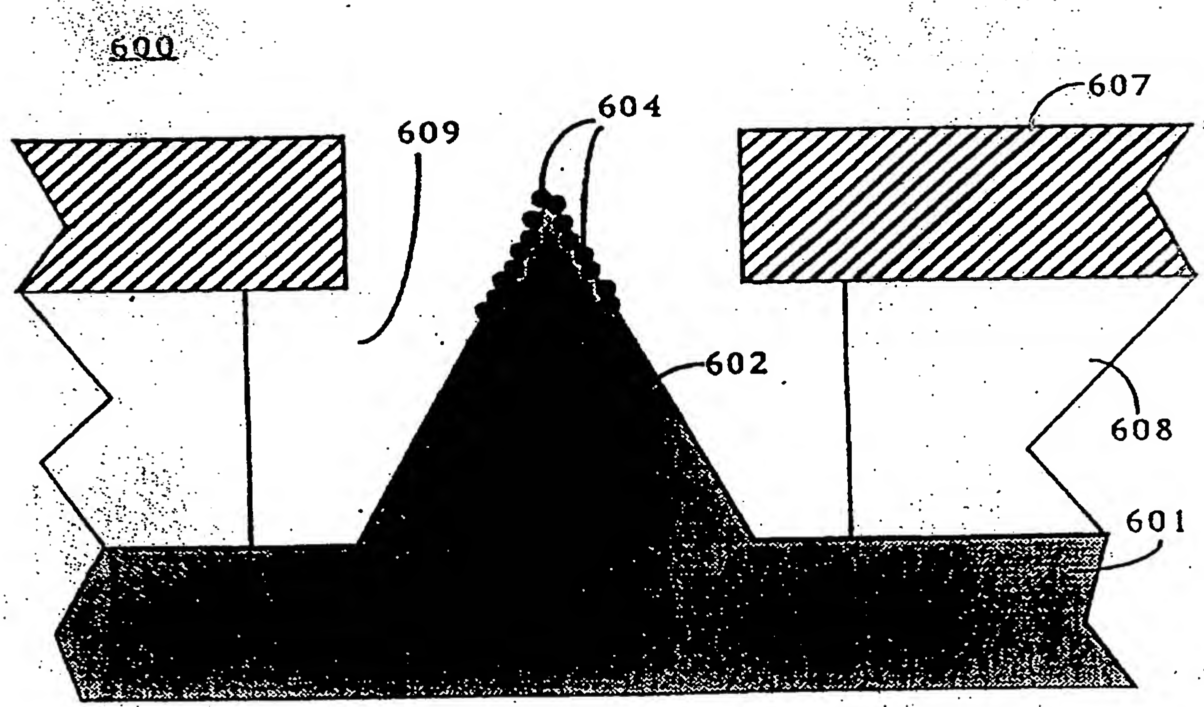

图. 6C

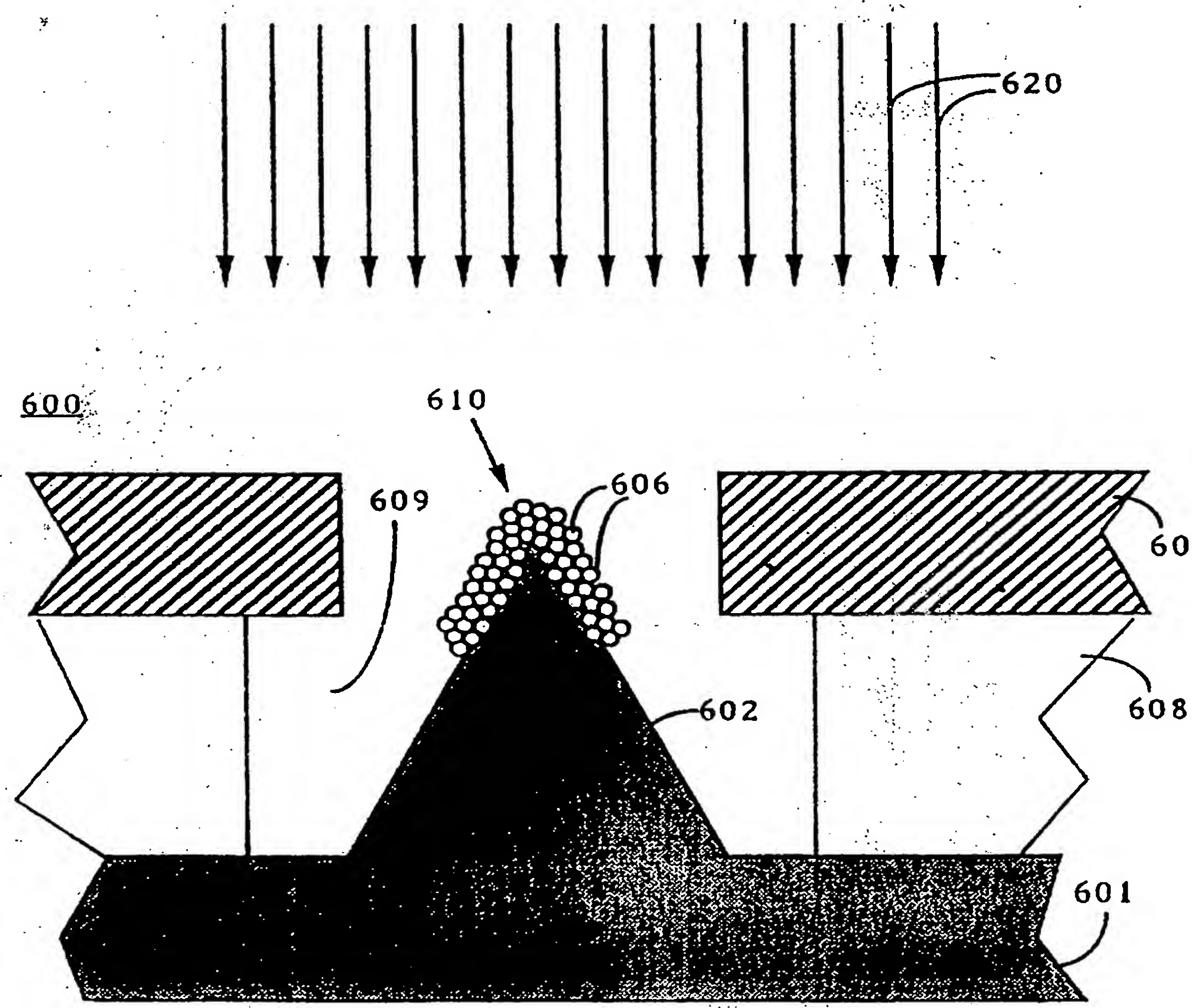

图. 6D

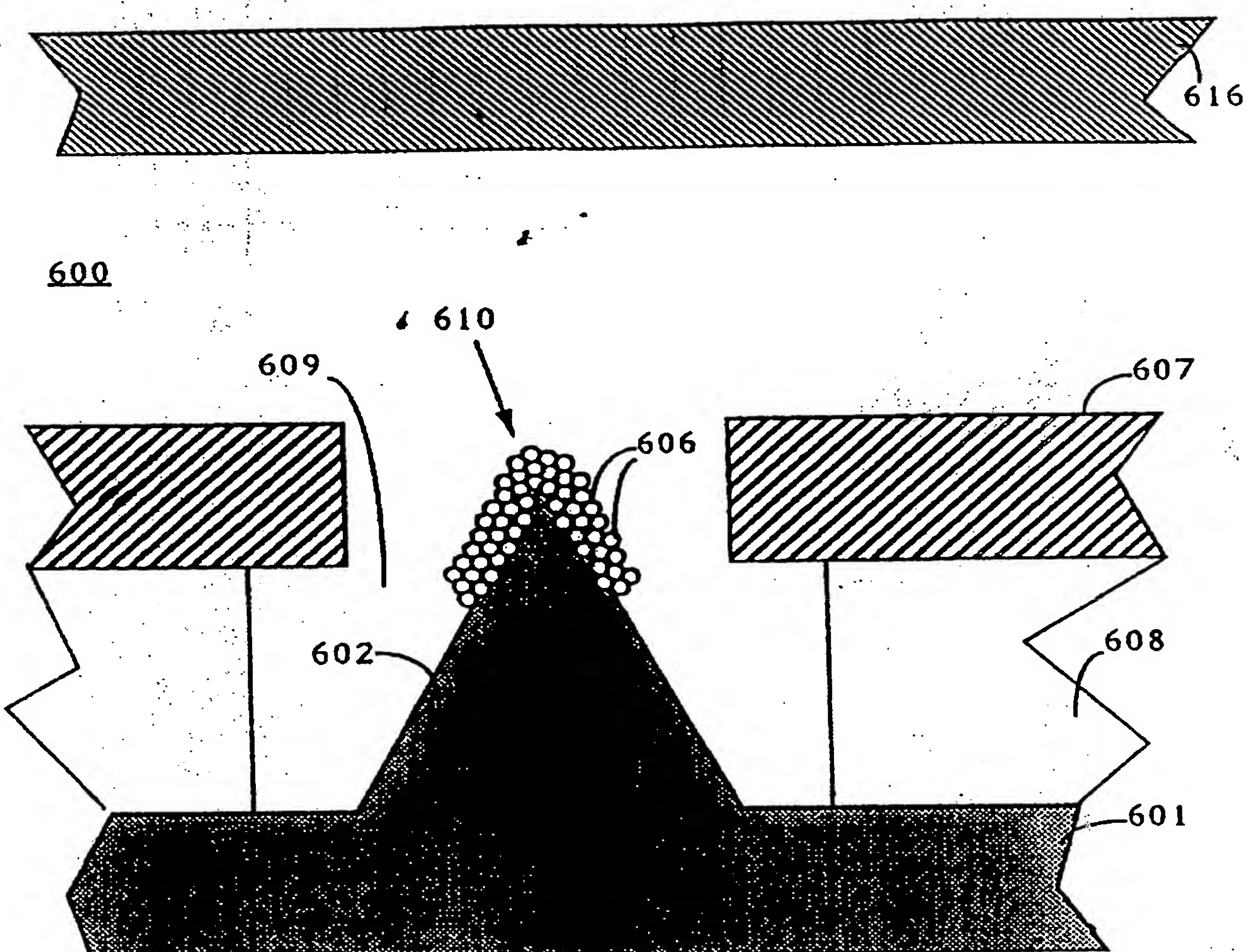

图. 6E

Reference 1

A FIELD EMISSION ELECTRON SOURCE EMPLOYING A DIAMOND COATING AND METHOD FOR PRODUCING SAME

The present invention relates generally to field emission electron devices, and more particularly to field emission electron devices and methods of producing field emission electron devices employing low/negative electron affinity coatings.

Field emission devices employing preferentially shaped conductive/semiconductive electrodes as electron emitters are known in the art. The prior art electron emitters are known to exhibit undesirable characteristics such as high operating voltages, surface instability, and susceptibility to ion bombardment damage.

Accordingly there exists a need for electron devices employing an electron emitter electron source which overcomes at least some of the shortcomings of the prior art electron sources.

This need and others are substantially met through provision of a method for forming a field emission electron emitter including the steps of providing a selectively shaped conductive/semiconductive electrode having a major surface, implanting ions, as nucleation sites, onto at least a part of the major surface of the conductive/semiconductive electrode, and growing diamond crystallites selectively at at least some of the nucleation sites, such that an electron emitter comprising a coating of diamond disposed on at least a part of the major surface of the selectively shaped conductive/semiconductive electrode is formed.

This need and others are further met through provision of a field emission electron device including a field emission electron emitter with a selectively formed conductive/semiconductive electrode having a major surface, a plurality of ion implanted nucleation sites disposed on the major surface of the conductive/semiconductive electrode, and at least a first diamond crystallite disposed on the major surface of the conductive/semiconductive electrode and at a nucleation site of the plurality of nucleation sites, an emission controlling electrode proximally disposed with respect to the electron emitter for controlling the emission rate of electrons from the electron emitter, and an anode for collecting emitted electrons.

FIG. 1 is a schematic representation of ion implantation apparatus.

FIG. 2 is a cross sectional depiction of ion implantation apparatus.

FIG. 3 is a diagram of diamond growing environment apparatus.

FIGS. 4A-4C are side elevation depictions of structures which are realized by performing various steps of a method in accordance with the present invention.

FIGS. 5A-5D are side elevation depictions of structures which are realized by performing various steps of another method in accordance with the present invention.

FIGS. 6A-6E are side elevation representations of structures which are realized by performing various steps of yet another method in accordance with the present invention.

Referring now to FIG. 1 there is shown a representative schematic depiction of one embodiment of ion implantation apparatus. An evacuated enclosure 101 is provided wherein an ion source 106 and a substrate (target) holding fixture 103 are disposed. An ion material source aperture 105 is provided,

as shown, to supply the ion source 106 with material. An evacuation port 102 is provided to which an evacuating device, not shown, may be operably coupled to evacuate enclosure 101. During operation of the implantation apparatus an ion beam 107 is directed to a target 104, due to an electric field which is induced by a voltage source 108, at least some of the ions of the ion beam 107 are implanted onto target 104.

FIG. 2 is a side elevation depiction of target (substrate) 104 whereon/wherein ions 201 have been implanted. Ions are selectively implanted to a desired depth in the material of target 104 depending on the strength of the associated accelerating electric field (not shown). Correspondingly, the electric field strength may be selected so that implanted ions will be substantially disposed onto the surface of target 104.

FIG.3 is a representative schematic depiction of one embodiment of diamond growing environment apparatus. An evacuated enclosure 301 is provided wherein a substrate (target) holder 305 and a heating element 304 are disposed. A source tube 303, which is a part of a gas supply manifold, provides a source of reactive gas constituents into the diamond growing environment. Enclosure 301 is suitably evacuated by operably coupling an evacuation pump (not shown) to an evacuation port 302. During operation a substrate 306 is disposed on substrate holder 305 to which heating element 304 is also proximally disposed. Power source 307 provides electrical current through heating element 304 to heat substrate 306 and in the presence of appropriate gas constituents a reaction occurs at the surface of substrate 306 during which diamond is grown.

Diamond growth is at least partially dependent on an ability to nucleate at the surface of a material. In many methods of diamond formation the nucleation is random and not well distributed giving rise to undesirable and incomplete film growth. Carbon ions implanted at a surface of substrate 306 provides a substantially uniformly distributed plurality of nucleation sites from which diamond growth is initiated.

Referring now to FIG. 4A there is shown a side elevation depiction of a structure 400 which is realized by performing various steps in accordance with a method of the present invention. Structure 400 includes a selectively shaped layer 401 of conductive/semiconductive material, having at least a major surface, with the selective shaping, in this specific embodiment, being a generally conically shaped protrusion forming an electrode 402. Layer 401 is selectively shaped by any of many known techniques including, but not limited to, anisotropic etching and ion milling. A carbon ion beam, depicted by arrows 405, provides for implantation of carbon nucleation sites 404 at the major surface of electrode 402.

Alternatively, and with reference to FIG. 4B, layer 401 is a supporting substrate which is provided with a layer 403 of patternable material, such as photoresist or insulator material, having at least one aperture 409 therethrough. Aperture 409 is selectively formed by photosensitizing, patterning and developing photoresist or by etching insulator material as may be required. A conductive/semiconductive electrode 402 is substantially disposed within aperture 409 and on the layer 401. A carbon ion beam, depicted by arrows 405, provides for implantation of nucleation sites 404 at the conductive/semiconductive electrode 402, with the remainder of layer 401 being protected

from implantation of nucleation sites 404 by layer 403. The layer of patternable material 403 may be removed subsequent to the implantation of nucleation sites 404.

FIG. 4C is a side elevation depiction of structure 400 as described previously with reference to FIGS. 4A & 4B and having undergone additional steps of the method in accordance with the present invention. A source of reactant material, depicted by arrows 420, disposed in an intervening region between conductive/semiconductive electrode 402 and a proximal heating element (element 304 described previously with reference to FIG. 3) gives rise to growth of diamond crystallite 406 at the implanted carbon nucleation sites.

The resultant conductive/semiconductive electrode 402 on which is disposed a coating of diamond crystallite 406 comprises a field emission electron emitter exhibiting a number of desirable operating characteristics including reduced voltage operation, improved surface stability, and reduced susceptibility to ion bombardment damage. Incorporation of implanted carbon nucleation sites 404 provides a mechanism for improved diamond crystallite coverage and discourages the formation of a non-uniform coating which may include undesirably large crystallite growth.

FIG. 5A is a side elevation depiction of a structure 500 which is realized by performing steps of another method in accordance with the present invention. A supporting substrate 501 is provided. A layer 508 of insulator material having an aperture 509 formed therethrough is disposed on supporting substrate 501. A conductive/semiconductive electrode 502, formed as described previously with reference to FIGS. 4A & 4B, is disposed within aperture 509 and on supporting substrate 501. A layer 507 of conductive/semiconductive material is disposed on layer 508 substantially conformally with respect to aperture 509 such that aperture 509 is further defined through layer 507. A layer 522 of patternable material is deposited on layer 507. A carbon ion beam, depicted by arrows 505, provides for implantation of nucleation sites 504 at conductive/semiconductive electrode 502. Layer 522 may be removed subsequent to the implantation of the nucleation sites 504.

Alternatively, and with reference to FIG. 5B, patternable layer 522 described in FIG. 5A is omitted with the result that at least some nucleation sites 504 are deposited on the conductive/semiconductive layer 507.

FIG. 5C is a side elevation depiction of structure 500 as described previously with reference to FIGS. 5A & 5B and having undergone additional steps of the method. A source of reactant material, depicted by arrows 520, 15 disposed in an intervening region between conductive/semiconductive electrode 502 and a proximal heating element (see FIG. 3), gives rise to growth of diamond crystallite 506 selectively at the implanted carbon nucleation sites. The combination of conductive/semiconductive electrode 502 with a coating of diamond nucleation sites 506 produces an improved electron emitter 510.

FIG. 5D is a side elevation depiction of structure 500 described previously with reference to FIG. 5C and further comprising an anode 516, distally disposed with respect to electron emitter 510, for collecting any electrons which are emitted by electron emitter 510. Layer 507, since it is formed of conductive/semiconductive material, functions as an emission controlling electrode for controlling the rate of electrode emission. A field emission device (structure 500) employing an electron emitter

comprised of a diamond coating, formed in accordance with the method of the present invention described in FIG. 5D, may be employed advantageously in applications known in the art. Utilizing implanted nucleation sites from which diamond crystallite growth may be initiated provides for a more uniform coating. Since coating thicknesses of 10A to 5000A are desirable it is an important feature of coating formation that irregularities in coating thickness and coverage be minimized. Other methods of realizing diamond film growth do not provide for substantially uniform growth thickness and coverage.

FIG. 6A is a side elevation depiction of a structure 600, similar to that described previously with reference to FIG. 5B, wherein similar features initially described in FIG. 5B are similarly referenced beginning with the numeral "6". FIG. 6A further depicts that an ion implantation source 640 provides an ion beam 605 from which carbon nucleation sites 604 are implanted on the conductive/semiconductive electrode 602. In the instance of FIG. 6A, an externally provided voltage source 610 is operably coupled between ion implantation source 640 and supporting substrate 601. A second externally provided voltage source 612 is operably coupled between conductive/semiconductive layer 607 and supporting substrate 601. Alternatively, the structure of FIG. 6A may employ a conductive/semiconductive electrode formed as described previously with reference to FIG. 4A. By applying a suitable voltage to conductive/semiconductive layer 607, ions included in the ion beam 605 are repelled from the region proximal to the periphery of conductive/semiconductor layer 607 and correspondingly toward a desired small part of the surface of conductive/semiconductive electrode 602. This redirection of ion beam 605 results in implantation of nucleation sites 604 substantially at only a selected part of the surface of conductive/semiconductive electrode 602.

FIG. 6B is a side elevation view of structure 600 wherein a different feature is utilized to obtain the results described in FIG. 6A. In this modified method aperture 609 is partially closed by employing a low angle material deposition, as is known in the art, to provide a partial closure layer 614. A carbon ion beam, depicted by arrows 605, provides for implantation of nucleation sites 604 at conductive/semiconductive electrode 602.

FIG. 6C depicts structure 600 after having undergone an additional process step wherein closure layer 614 is removed.

FIG. 6D is a side elevation depiction of structure 600 having undergone additional steps of the method wherein a source of reactant material, depicted by arrows 620, disposed in an intervening region between conductive/semiconductive electrode 602 and a proximal heating element (see FIG. 3), gives rise to growth of diamond crystallite 606 as desired at the implanted carbon nucleation sites. In the instance of the structure of FIG. 6D the diamond crystallite growth takes place on only a part of the exposed part of conductive/semiconductive electrode 602. The combination of conductive semiconductive electrode 602 with the coating diamond crystallite 606 forms an improved electron emitter 610.

FIG. 6E is a side elevation depiction of structure 600 further comprising an anode 616 distally disposed with respect to electron emitter 610 for collecting electrons which are emitted by electron emitter 610. Conductive/semiconductive layer 607 functions as an emission controlling electrode for

controlling the rate of electrode emission. The field emission device employing an electron emitter including a diamond coating, formed in accordance with the method of the present invention described in FIGS. 6A-6E, may be employed advantageously in applications known in the art. Utilizing implanted nucleation sites from which diamond crystallite growth is initiated provides for a more uniform coating. Since coating thicknesses on the order of 10k are desirable it is an important feature of coating formation that irregularities in coating thickness and coverage be minimized. Other methods of realizing diamond film growth do not provide for substantially uniform growth thickness and coverage.

What is claimed is:

1. A method for forming a field emission electron emitter characterized by the steps of:

providing a selectively shaped conductive/semiconductive electrode (402) having a major surface,

implanting ions, as nucleation sites (404), onto at least a part of the major surface of the conductive/semiconductive electrode (402),and

growing diamond crystallites (406) selectively at at least some of the nucleation sites (404), such that an electron emitter comprising a coating of diamond disposed on at least a part of the major surface of the selectively shaped conductive/semiconductive electrode is formed.

2. The method of claim 1 further characterized in that the step of implanting ions includes implanting carbon ions.

3. The method of claim 1 further characterized in that the step of providing a conductive/semiconductive electrode includes anisotropic etching of semiconductor material.

4. A method as claimed in claim 1 further characterized by the steps of:

providing a supporting substrate (401),

depositing a layer of patternable material (403) on the supporting substrate (401),

patterning the layer of patternable material (403) to provide an aperture (409) therethrough,

providing the selectively shaped conductive/semiconductive electrode (402) disposed substantially within the aperture (409) and on the supporting substrate (401),

performing the step of implanting ions (404), and

removing substantially all of the layer of patternable material (403), after which the step of growing diamond crystallites (406) is performed.

5. The method of claim 4 further characterized in that the step of providing a conductive/semiconductive electrode (402) includes the step of forming the electrode by a substantially normal deposition of conductive/semiconductive material.

6. The method of claim 4 further characterized in that the step of implanting ions includes the steps of:

depositing a layer of conductive/semiconductive material (607) on the patterned layer of patternable material (608),

providing ion implantation apparatus (640),

disposing the conductive/semiconductive electrode (602) in the ion implantation apparatus (640) and implanting ions, as nucleation sites (604), onto at least a part of the surface of the conductive/semiconductive electrode (602),

providing a first voltage source (610) operably coupled between the supporting substrate (601) and the ion implantation apparatus (640) such that an ion accelerating electric field is provided substantially between the ion implantation apparatus (640) and the conductive/semiconductive electrode (602), and

providing a second voltage source (612) operably coupled between the supporting substrate (601)

and the conductive/semiconductive layer (607) such that an ion repelling electric field is provided substantially between the conductive/semiconductive layer (607) and the conductive/semiconductive electrode (602), such that at least some of the ions are selectively directed to a selected part of the conductive/semiconductive electrode (602).

7. The method of claim 4 and further characterized by the steps of:

depositing a layer of conductive/semiconductive material (607) on the patterned layer of patternable material,

depositing a layer of material (614) onto the conductive/semiconductive layer (607) by means of low angle deposition such that the etched aperture (609) is selectively partially closed, and

removing substantially all of the layer (614) of material subsequent to the implantation of the ions (604), such that carbon ions are substantially selectively implanted onto a selected part of the surface of the conductive/semiconductive electrode (602).

8. A field emission electron emitter characterized by:

a selectively formed conductive/semiconductive electrode (402) having a major surface,

a plurality of ion implanted nucleation sites (404) disposed on the major surface of the conductive/semiconductive electrode (402), and

at least a diamond crystallite (406) disposed on the major surface of the conductive/semiconductive electrode (402) and at a nucleation site (404) of the plurality of nucleation sites.

9. A field emission electron emitter as claimed in claim 8 further characterized in that the diamond crystallite (406) disposed on the major surface forms a substantially uniform diamond coating disposed on at least a part of the major surface of the conductive/semiconductive electrode (402)

A FIELD EMISSION ELECTRON SOURCE EMPLOYING A DIAMOND COATING AND METHOD FOR PRODUCING SAME

Abstract of the Disclosure

The invention relates to a field emission electron device employing an electron emitter comprised of a coating of diamond material disposed on a surface of a selectively formed conductive/semiconductive electrode (402). The invention also relates to a method of forming the device including a step wherein carbon ions are implanted at a surface of a conductive/semiconductive electrode to function as nucleation sites for the diamond formation.